

# **Intra- and inter-specific variation in alarm pheromone produced by *Solenopsis* fire ants**

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# 1. Introduction



Common name: **red imported fire ant**

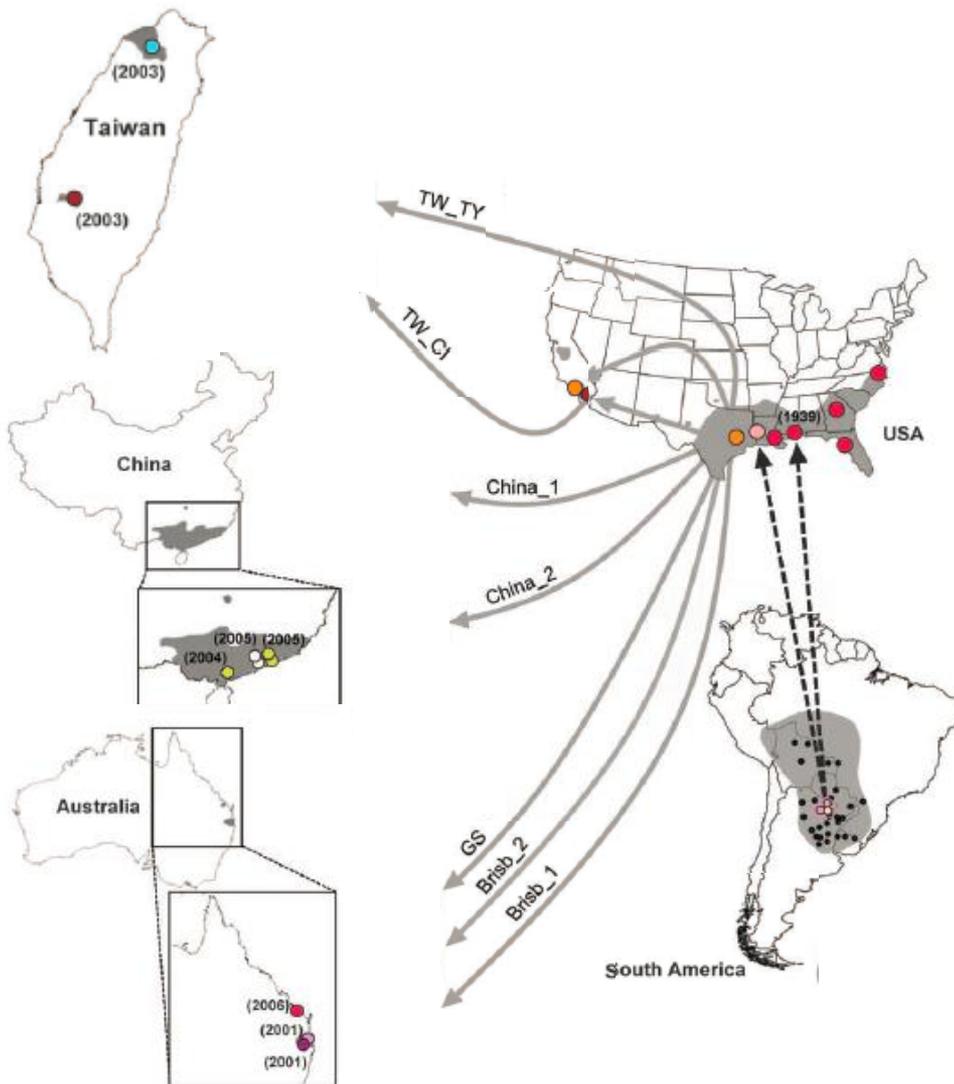
Scientific name: *Solenopsis invicta* **Buren** (Insecta:

Hymenoptera: Formicidae: Myrmicinae)



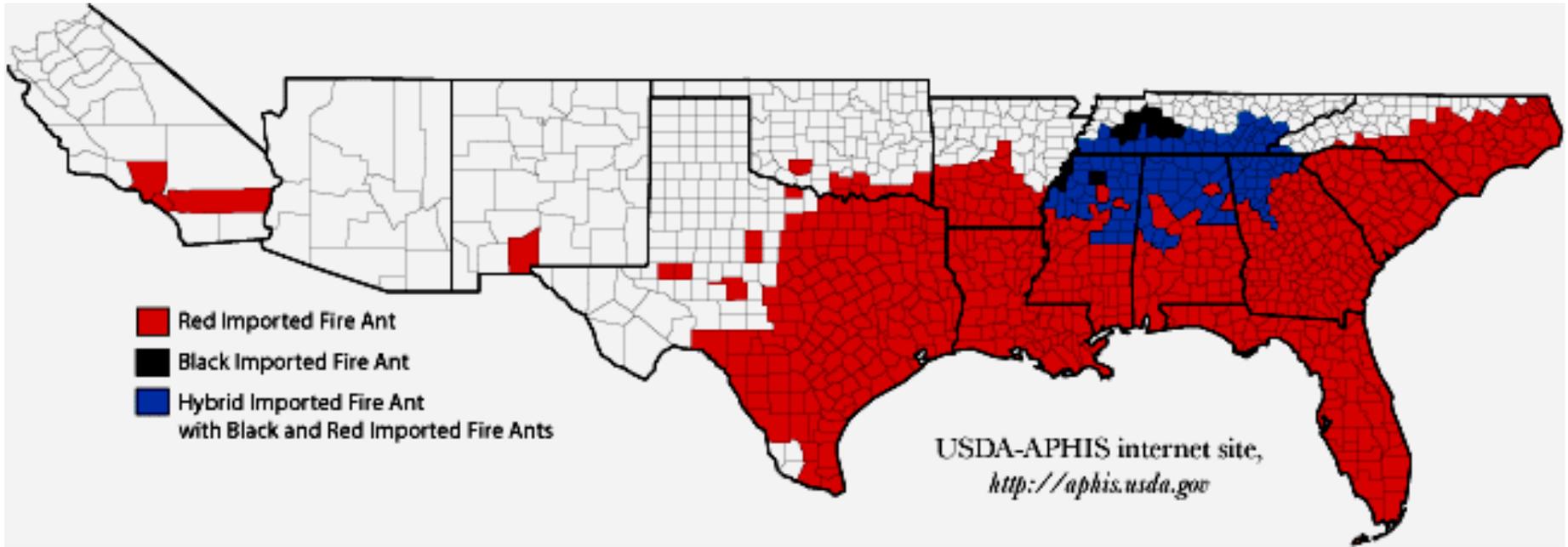
- ✓ Insecta: Hymenoptera: Formicidae: Myrmicinae
- ✓ A fire ant colony consists of three castes - workers, alates and queen(s)

# Global invasion history of the fire ant *S. invicta*



- ✓ Red imported fire ants (RIFA)
- ✓ Originate from South America
- ✓ Shipped to United States
- ✓ Introduced to Australia, China, New Zealand...

# Geographic distribution of fire ants



[http://www.extension.org/pages/Geographic\\_Distribution\\_of\\_Fire\\_Ants](http://www.extension.org/pages/Geographic_Distribution_of_Fire_Ants)

Two species of imported fire ants (IFA) were accidentally introduced into USA through Mobile, Alabama

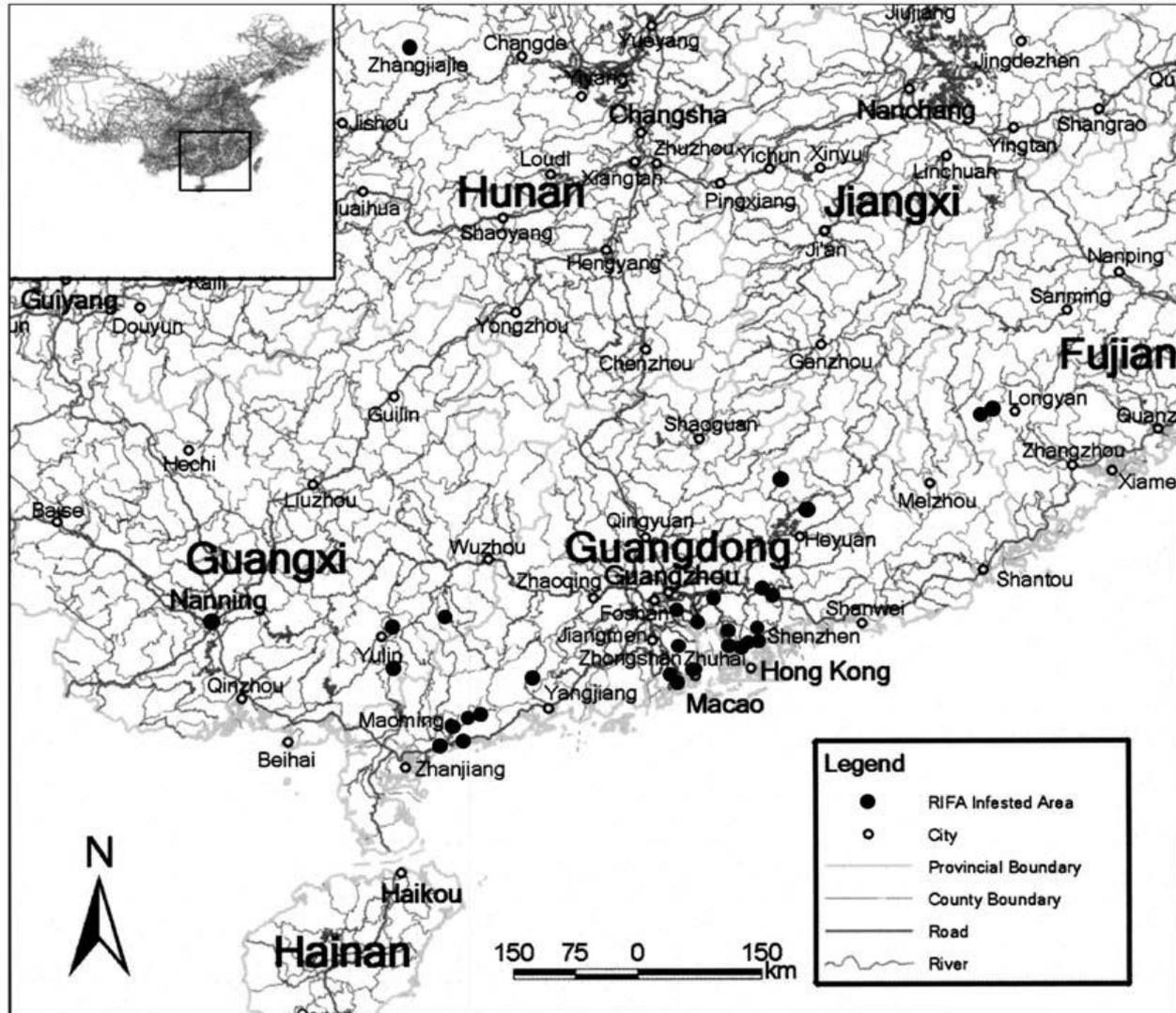
*Solenopsis richteri* (Black) 1918

*Solenopsis invicta* (Red) 1930's

*S. invicta* × *S. richteri* (Hybrid) 1985

Native species: *S. geminata*

# Distribution of IFA in China



# Impact of fire ant populations

- ✓ **Reduce native and competitor species**

Toxic to other species or compete for food and nesting resources

- ✓ **Ecological Impact**

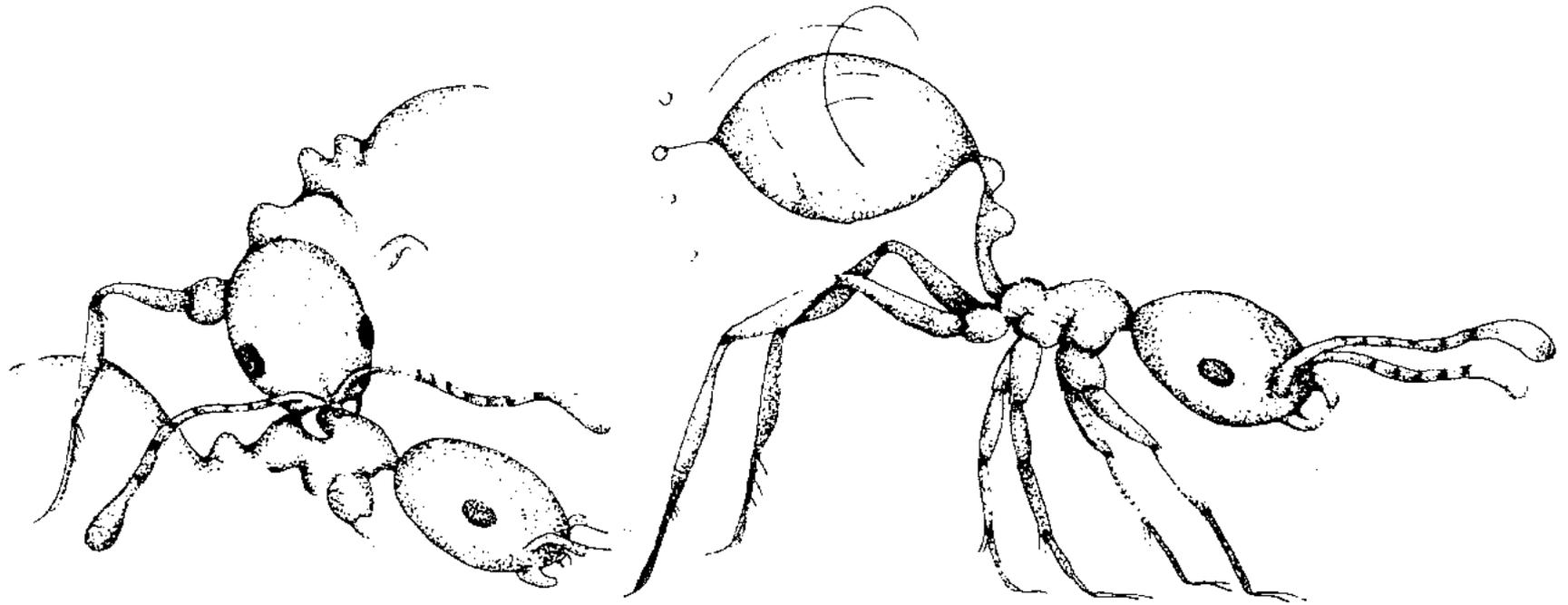
Aggressive predator: plants, seeds, insects  
numerous ant mounds at high density

- ✓ **Health effects**

RIFA stings: allergic reactions can result in death



# Fire ant alarm behavior and invasion success



## Glandular source of alarm behavior



**Mandibular gland**

**(Alarm pheromones)**

# Isolation of a Pyrazine Alarm Pheromone Component from the Fire Ant, *Solenopsis invicta*

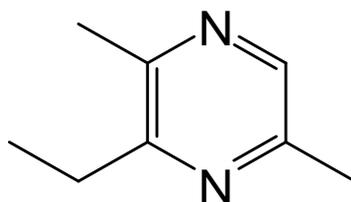
Robert K. Vander Meer · Catherine A. Preston ·  
Man-Yeon Choi



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**Abstract** Alarm pheromones in social insects are an essential part of a complex of pheromone interactions that

**Keywords** Alarm pheromone · Pyrazine · Mandibular gland · Fire ant



**2-Ethyl-3,6-dimethyl pyrazine  
(Alarm pheromone)**

2-Ethyl-3,(5 or 6)-dimethylpyrazine (CAS No. 27043-05-6), a heterocyclic, nitrogen-containing compound, is used in the food industry as a flavor ingredient for its characteristic roasted odor and flavor, reminiscent of roasted cocoa or nuts. Pyrazines, including 2-ethyl-3,(5 or 6)-dimethylpyrazine, are widely distributed in foods and because of their natural unavoidable occurrence in cooked food; therefore, pyrazine compounds, including 2-ethyl-3,(5 or 6)-dimethylpyrazine, are commonly consumed in the daily diet. From Burdock GA and Carabin IG. Regulatory Toxicology and Pharmacology 2008, 50(3): 303-312

## 2. Hypothesis

**The quantity of alarm pheromone of ant nestmates mediates competitive response and relative fitness among sympatric fire ant species**

# 3. Methodology

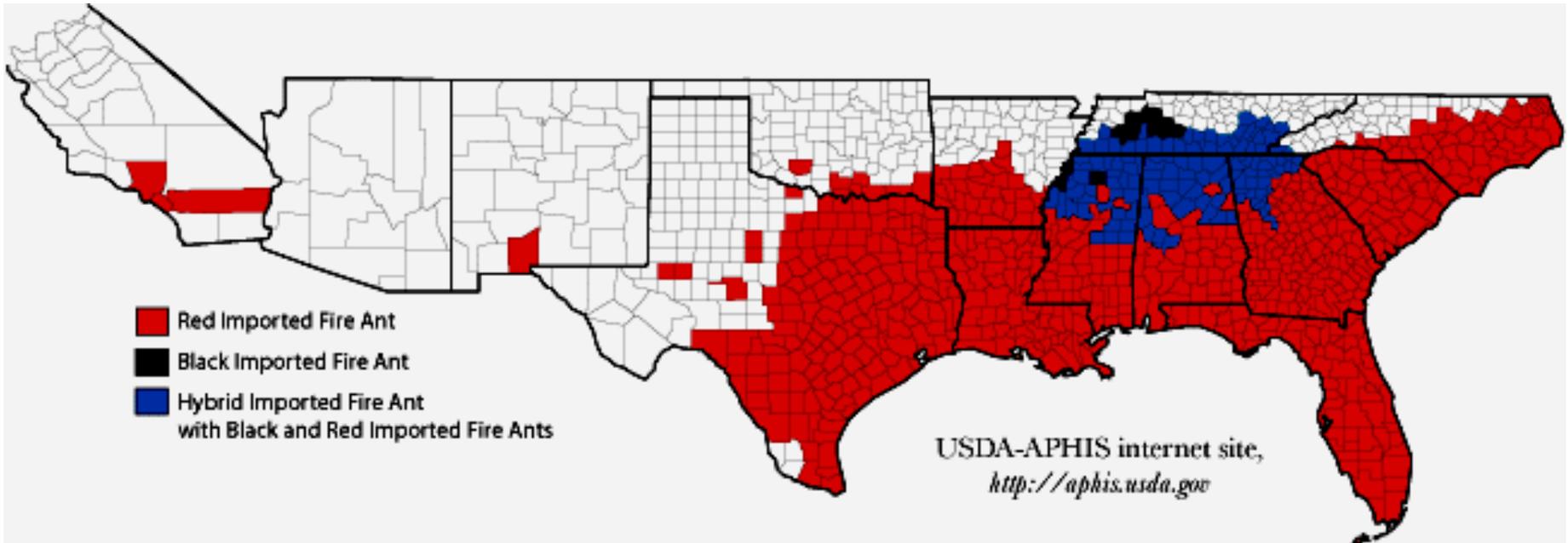
## Collection of fire ant colonies

*Solenopsis richteri* (Black)

*Solenopsis invicta* (Red) 1930's

*S. invicta* × *S. richteri* (Hybrid)

*Solenopsis geminata*

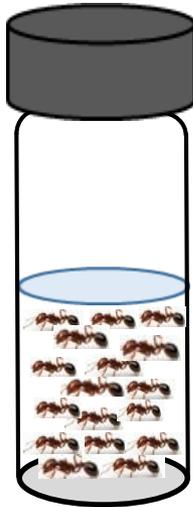


# Quantification of fire ant alarm pheromone component

Extraction

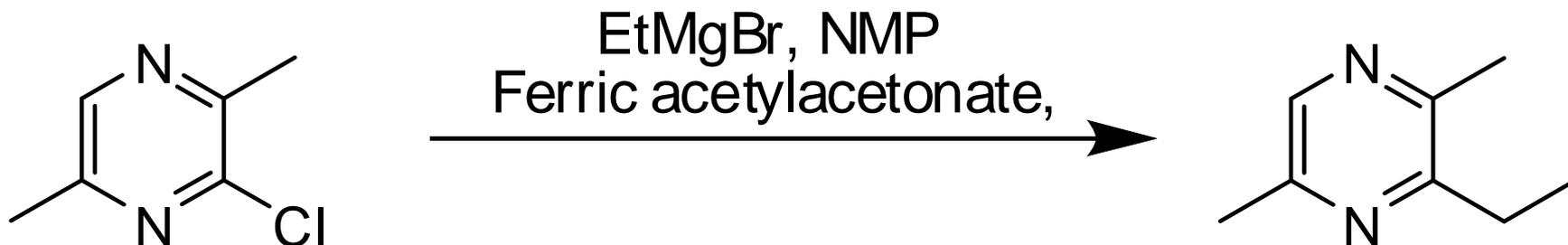


GC-MS quantification



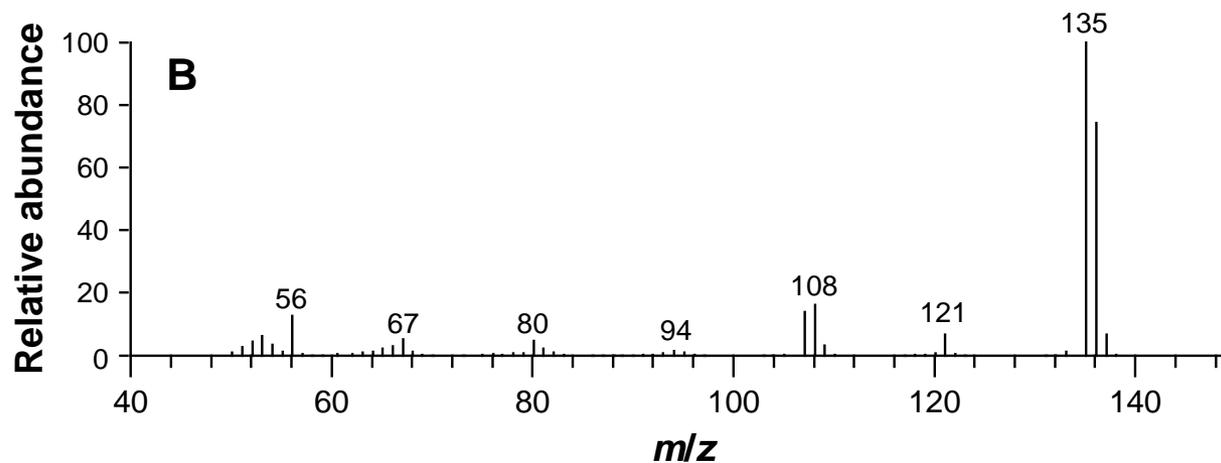
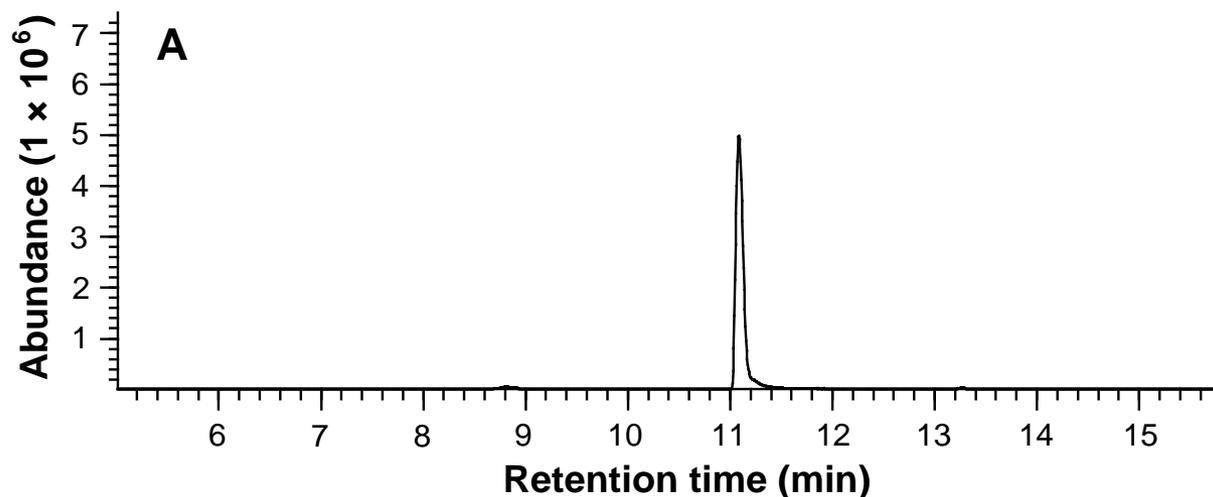
## 4. Results

### Synthesis of fire ant alarm pheromone



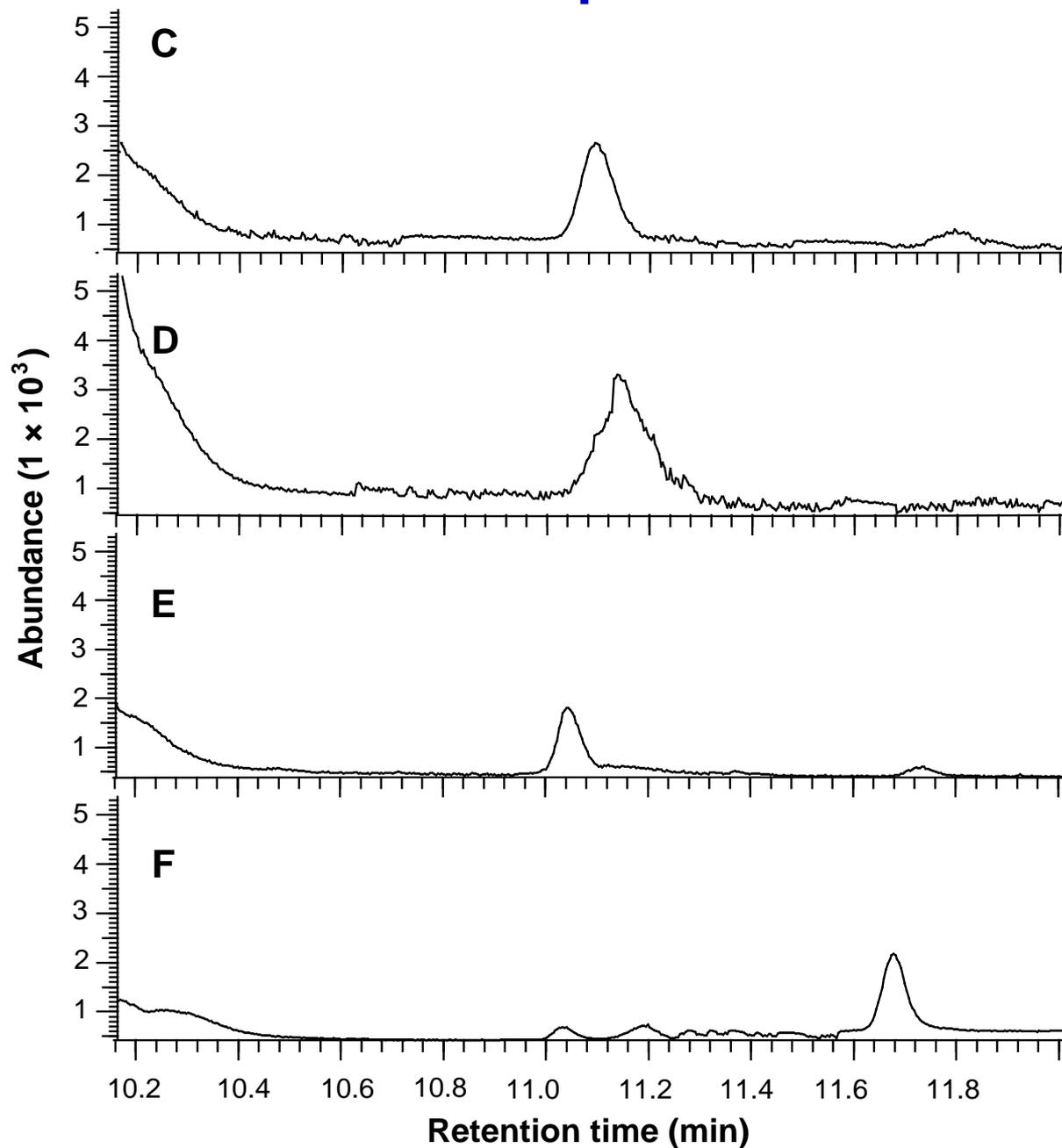
**Fang M., Cadwallader K. R., 2013.** Convenient synthesis of stable deuterium-labeled alkylpyrazines for use in stable isotope dilution assays. **Journal of Agricultural and Food Chemistry**, **61**, 3580-3588.

# GC-MS of synthesized fire ant alarm pheromone



**A, GC profile of authentic sample in full scan mode**  
**B, Mass spectra of 2-ethyl-3,6-dimethyl pyrazine**

# GC-MS of worker samples from different fire ant species



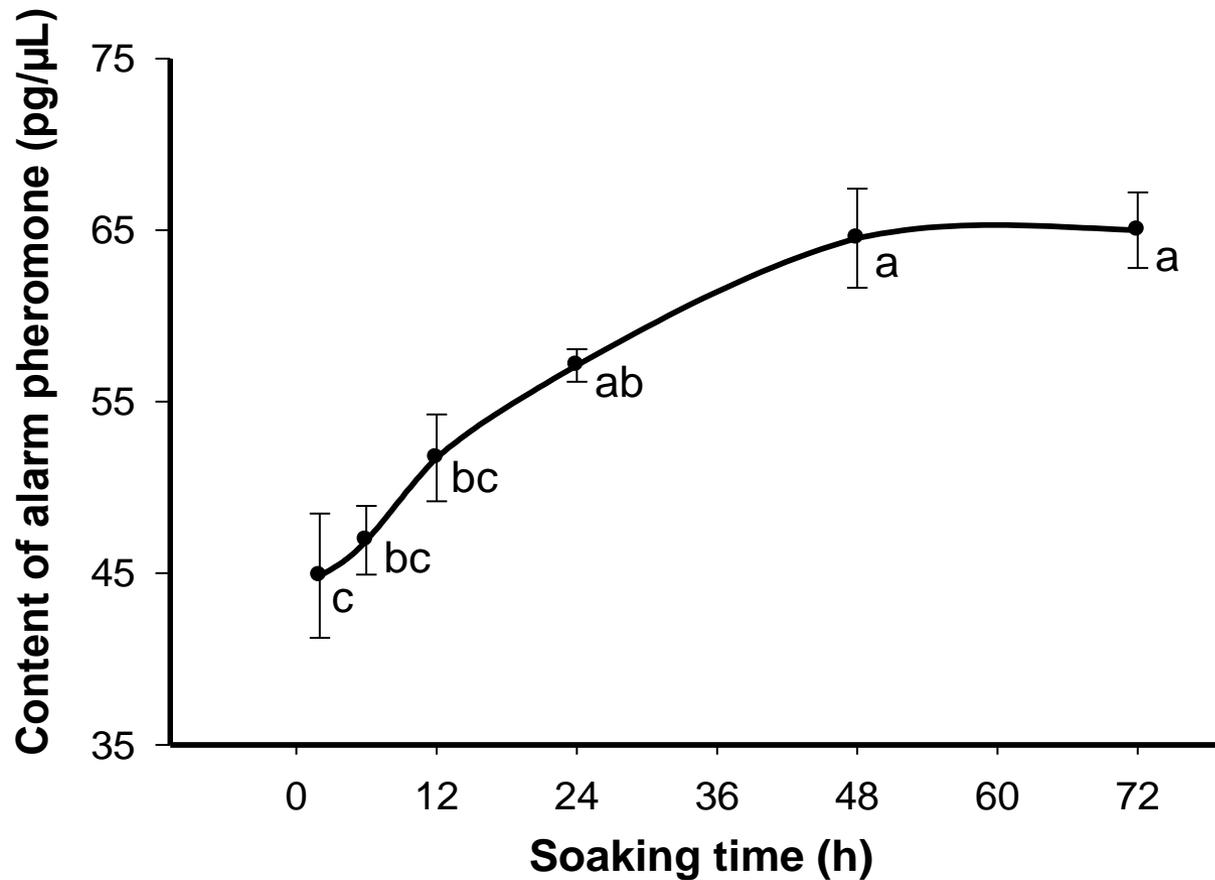
***C. S. richteri***

***D. S. invicta***

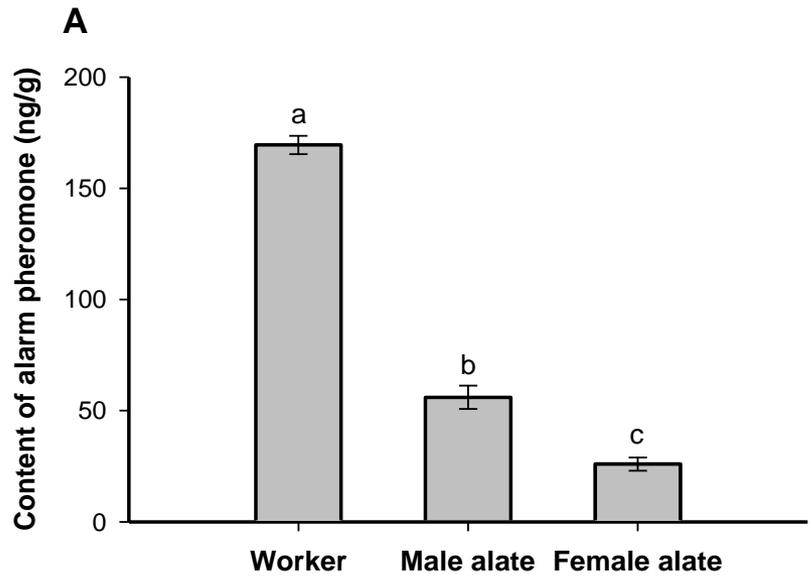
***E. Hybrid***

***F. S. geminata***

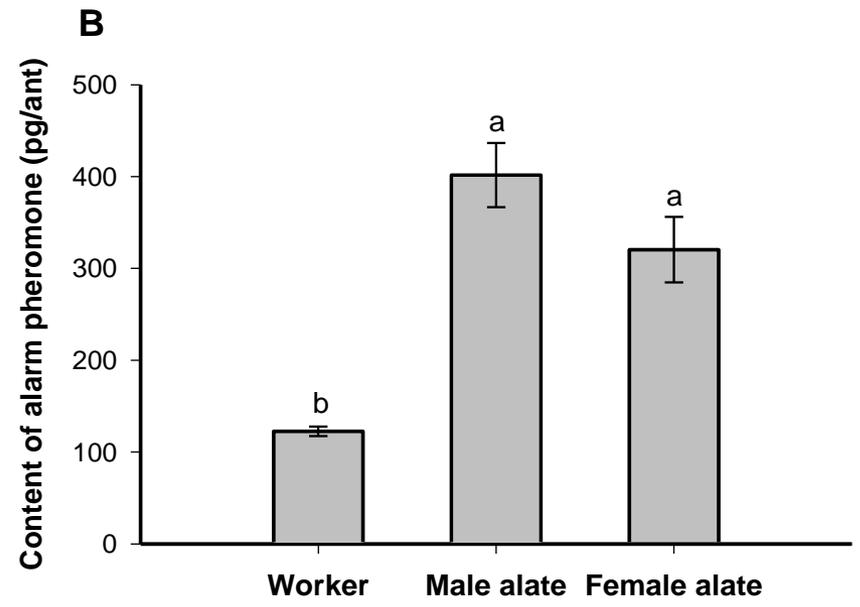
# Amounts of alarm pheromone in *S. invicta* workers as quantitated using whole body extracts at different soaking times



# Amounts of alarm pheromone in different castes of *S. invicta*

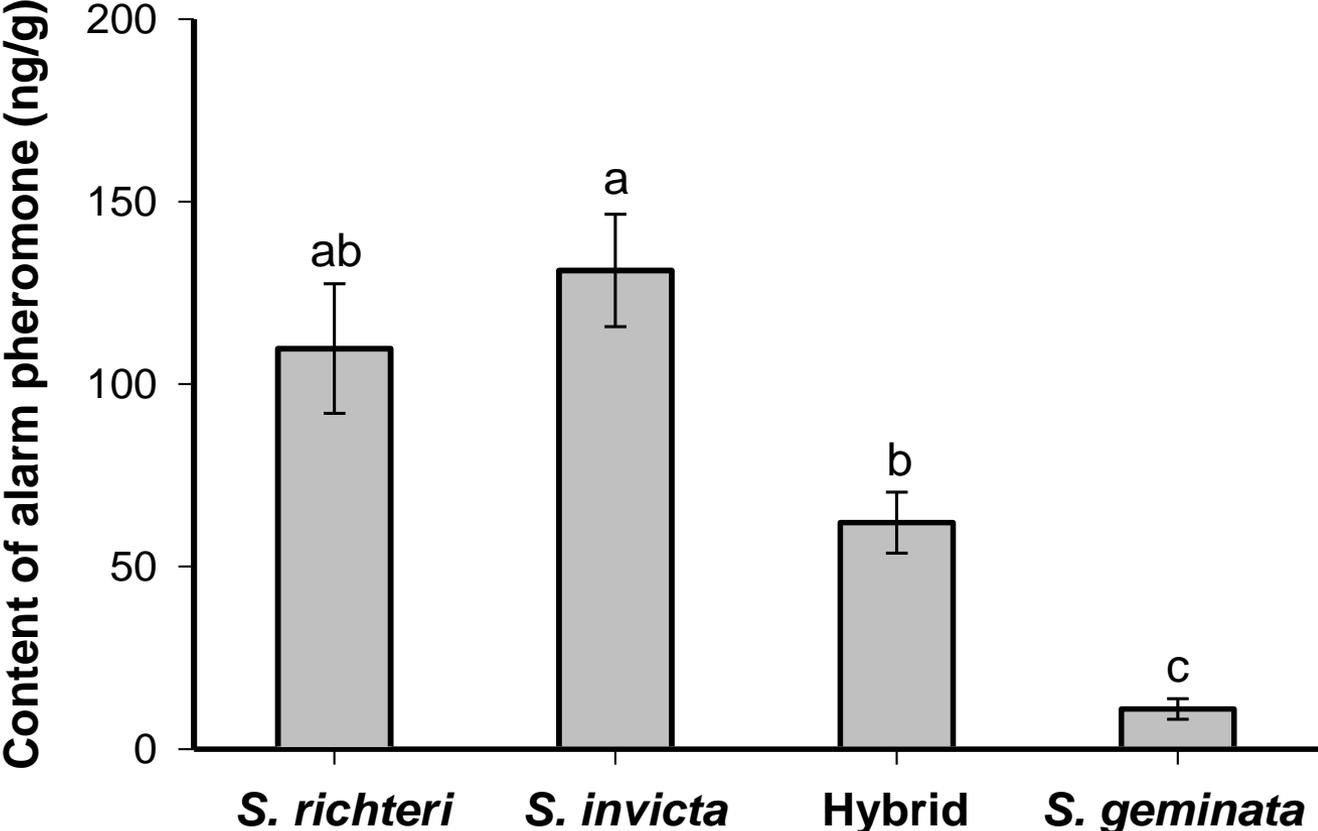


**Amount of alarm pheromone per gram of extracted ant bodies**



**Amount of alarm pheromone per individual ant**

# Amount of alarm pheromone in different fire ant species

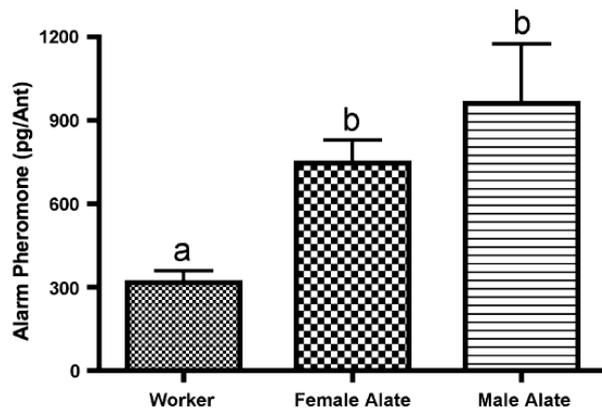


## 5. Conclusions and Discussion

### ➤ Intraspecific variation

Workers had more alarm pheromone than males or female alates by relative weight; however single worker individuals contained significantly less alarm pheromone than male and female alate individuals

### Other role of alarm pheromones: sex pheromone?



Vander Meer R. K. et al. 2010 J. Chem. Ecol. 34: 163-170

## ➤ Interspecific variation

Workers of the three imported fire ant species (*S. richteri*, *S. invicta*, and hybrid) had significantly more alarm pheromone than a native fire ant species, *S. geminata*.

- Higher alarm pheromone contents may have favored invasion success of imported fire ants over native species.
- These results could explain the observed shifts in the spatial distributions of the three imported fire ant species resulting from the displacement of native fire ant species in southern United States.
- We can't rule out higher concentration of components in native fire ants other than 2-Ethyl-3,6-dimethylpyrazine.----- Future work

## 6. Acknowledgements

**Collaborators:  
Dr. Henry Fadamiro's lab  
Auburn University**



**Contributors:**



胡林



张文倩



*Thanks for your attention !*